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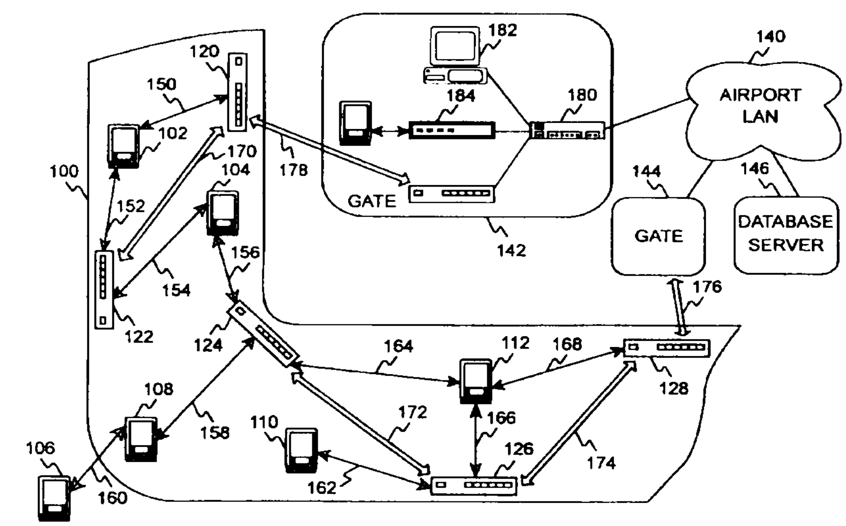
(54) **Title:** COMMUNICATION, LOCATION AND TRACKING SYSTEM



(57) **Abstract:** A tracking system for individuals or objects within a selected region, including identifying the vicinity of the selected region in which the individual or object is located, and means for the individual or object to selectively provide information for the system, all done in real time. The system includes means (16) to selectively provide information to the system, such as a button or similar device mounted on a transponder (20) carried by an individual, the individual activating the button in response to a query or paging instruction from the system. The selective communication from the user may also include queries or instructions for further information from the communication system, such as an information request as to travel details, the location of facilities within the terminal, or goods or services for sale in the terminal.

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COMMUNICATION, LOCATION AND TRACKING SYSTEM

TECHNICAL FIELD

This invention relates to communication systems and more particularly to location and identification systems. The invention is directed particularly, but not solely, toward locating, tracking, and communicating with individuals or tracking inanimate objects.

BACKGROUND OF THE INVENTION

There are many industries in which it would be desirable to track people or objects in real time. For example, it has long been recognized that air travel congestion results in massive revenue loss in airline ground costs through airport terminal delays. One particular area that has not been targeted since the beginning of commercial air transport is trying to reduce the time a passenger spends in the transport terminal.

In particular, it appears that airline passengers are becoming increasingly complacent about boarding the aircraft, as they know their bags are on board and the aircraft cannot leave either without them or without unloading their bags. Unloading bags on a Boeing 747 aircraft for example can take sixty to ninety minutes by the time the relevant containers are found and removed. This results in a delay costing tens of thousands of dollars. The flow-on effects of such delays are significant, involving loss of slots, missing connections, network disruption and crews going over time.

This problem has not been addressed, and effective methods of reducing the resultant delays have not been identified. US Patent No 5914671 to Micron Inc. discloses a system for locating individuals in an airport environment. The system uses transponder devices that are carried by passengers. The transponders are responsive to the interrogator. The interrogator repeatedly transmits a command to the transponder devices using different antennas. The transponder transmits identifying data in response to a command if the transponder is within communications range of the antenna that sends the command. In this way, the individual is located.

The disadvantages with the system of US5914671 include:

1. There is no provision for the wearer or user of the transponder to interact with the system.
2. If one of the transponders fails, then the system will not work properly.
3. The range of the system cannot be easily extended.

4. Tracking information is not provided in real time and the location information cannot be easily stored for subsequent use e.g. data mining.
5. The system infrastructure is not used efficiently by also serving other purposes. For example, it would be highly desirable if a user could use the transponder device to find out further information about when their flight is leaving, or other available seats on their flight, or general airport information. It would also be helpful if a user could use the transponder device as a way of interfacing with other communications or processing equipment that the user may have access to communication facilities provided at the airport.

DISCLOSURE OF THE INVENTION

It is an aspect of the present invention to provide improved communications, location or identification systems.

Another aspect of the invention is to provide a means for locating a passenger in a departure area, or locating an object within a selected area.

Still another aspect is to inform a passenger that boarding is in progress, either by providing a visual indicator or by voice communication.

A further aspect of the invention is to isolate the locating system from any passenger identification system.

Another aspect of the invention is to provide a means for locating non-passengers or other objects in the vicinity of airports, such as employees, contractors, ground support equipment, airplanes, luggage carts, or loading ramps at locations such as parking lots, roadways, runways, or tarmac.

The invention broadly comprises a trackable pass operable to locate and track people and objects to which the passes are attached or associated for security purposes, such as routes taken by people or objects under scrutiny, detection of people or objects that are located in restricted areas, detection of people or objects that need a "time-card" recognition, or detection of people or objects that need controlled automatic access to secure areas.

The invention may also comprise a tracking system for individuals or objects within a selected region, including means to identify the vicinity of the selected region in which the individual or object is located, and means for the individual or object to selectively provide information to the system, all done in real time.

The means to selectively provide information to the system may include a button or similar device mounted on a transponder carried by an individual, the individual activating the button in response to a query or paging instruction from the system.

The selective communication from the user may also include queries or instructions for further information from the communication system. If the system is used to track passengers and/or staff in a transportation terminal then this further information may, for example, comprise an information request as to travel details, the location of facilities within the terminal, or goods or services for sale in the terminal.

The system may store position information within the terminal of individual passengers and analyze this information to determine overall passenger flows within terminal spaces. The invention further provides for analysis of the information that has been retrieved so that passenger flows can be directed in a desired manner. For example, results of such an analysis may reveal spatial or other reasons for passenger movement backlogs. Also, such information may be significant for marketing purposes including rental value of shop space, etc., within the terminal.

In a still further aspect the invention may broadly be said to consist in a wireless communication and tracking system enabling individuals or objects with communication devices having compatible wireless communication protocols with the communication system to interface with the communication system, and/or further systems or processing devices accessible by the communication system.

Therefore, the invention provides for users of equipment such as cellular telephones, notebooks or laptops or PDA devices to access remote hosts, i.e., hosts that are remote from the communication and tracking system provided by using the wireless communication and tracking system.

In a further aspect the invention may broadly be said to comprise a tracking system for individuals or objects within a selected region, the system including a plurality of transceivers, and a self-healing means whereby the system remains operable if one of the transceivers malfunctions.

In a further aspect the invention may broadly be said to comprise a tracking system for individuals or objects within a selected region, the system including a plurality of individual transceivers and range extensions means whereby the range of the system can be extended without necessitating wiring installation.

The invention also comprises use of the system to transmit both voice and data.

Preferably the location information of individuals provided by the tracking data is used to target advertising of products or services to one or more specific individuals.

Preferably the tracking data is provided in a form suitable to allow effective data mining for purposes such as concession mapping in a retail environment such as a passenger terminal or a mall.

Preferably the system allows system-specific applications to be downloaded into user's communication devices.

DESCRIPTION OF THE DRAWINGS

An example of a preferred embodiment of the invention will now be described with reference to the following drawings in which

Fig. 1 is a diagrammatic illustration of a boarding pass according to the invention;

Fig. 2 is a diagrammatic illustration of another embodiment of a communications device according to the invention that may function as a boarding pass or be attached to a boarding pass;

Fig. 3 is a schematic diagram of the communications architecture of a system according to the invention;

Fig. 4 is a schematic diagram of an alternative communications architecture; and

Figs. 5A, 5B, and 5C illustrate how an object can be located.

DETAILED DESCRIPTION

The following description describes the invention when implemented in an airport environment. This is only an example of one implementation of the invention, and the invention and disclosure is not intended to be limited to this one application. The invention may be implemented in a number of other industries and environments. Thus it will be apparent from the disclosure of this document that the invention may be used in environments including but not limited to transportation terminals or stations, casinos, malls, entertainment complexes, factories, amusement parks, retail stores, gas stations, services such as banks, supermarkets, or restaurants, and courier or delivery services.

Referring to Fig. 1, a form of boarding pass, such as a hand-held computing device which may be used as an airline-boarding pass is shown generally referenced 10. Although this device is referred to in this document as a boarding pass, the device may also be referred to as a communication device that is designed to emulate or accommodate a boarding pass. The device may be a hand-held computing device such as a personal digital assistant, laptop computer, a

cellular telephone device, or a combination cellular telephone and hand-held computing device or any similar device with communication capability. This device is often called a mobile device.

The device 10 includes a visual display screen 12. This may be a liquid crystal display (LCD) in the preferred embodiment, but could comprise other forms of display if desired. A sound transducer 14 is also provided, for generating audible sounds that may be heard by a user. The transducer 14 may also include means to convert sounds generated by the user into signals of an appropriate form for transmission over the communications system with which the device 10 is intended to be used. Alternatively, a separate microphone (not shown) may be provided for this purpose if required. It will be appreciated that rather than having transducer 14 for conveying sound through the user, the user could have an earphone (not shown) or headphone set (not shown) which could be selectively connected to the device 10. Therefore the device 10 could also include a headphone socket 15.

A keypad area 16 is provided. This area may comprise only a single button, or a number of separate buttons, touch sensitive pads or the like for allowing the user to convey information or instructions to the system.

In Fig. 2 an alternative mobile device 20 is shown which may function as a boarding pass itself, but is primarily intended to be attached to a paper boarding pass. The device 20 in Fig. 2 may be provided as part of a clip to enable it to be clipped to the paper boarding pass and/or to other documents such as tickets etc. Rather than having an LCD screen this device has two LED's 22 and 24. When active, LED 22 indicates that the user should begin boarding the aircraft, and LED 24 indicates the user should go to the airline counter.

The communication system with which the devices 10 and 20 interact is provided in a transportation terminal in the example described below with respect to Figs. 3 and 4. It will be seen that the transportation terminal could be one for a large number of different modes of transportation, but will preferably be a departure area of an airport in view of the significant volumes of passenger traffic that airports need to accommodate. The departure area could be limited to the immediate area around departure gates, an entire concourse, or it could be the entire airport including the parking areas.

The communication system is a wireless system and in the preferred embodiment is based upon wireless technology presently referred to as Bluetooth technology. Bluetooth technology has been designed to allow wireless connection between various communication devices, such as mobile phones and desktop notebook computers. Transfer of data occurs in real

time. The protocols on which technology is based support point to point and point to multi-point connections.

At present, Bluetooth technology has been implemented in microchip products that incorporate a radio transceiver. Therefore, such microchips may be provided within the boarding pass devices 10 and 20 described above to effect communication with other microchips provided in the communication system of the transportation terminal. The Bluetooth technology has been designed to facilitate faster secure transmissions of data (including voice data) even when the devices are not within the line of sight. The frequency of operation of the radio transmissions is in globally available frequency bands, ensuring compatibility worldwide.

The technology also provides a universal bridge to existing data networks, peripheral interface, and a mechanism to form small private ad hoc groupings with connected devices away from fixed network infrastructures. The technology is also designed to operate in a noisy radio frequency environment. Further information about the Bluetooth technology is readily available to those skilled in the art to which the invention relates.

Referring to Fig. 3, an overall communication system architecture is illustrated. The boarding pass communication devices 102, 104, 106, 108, 110, and 112, each of which may comprise a device 10, as described above with respect to Fig. 1, or a device 20, as described above with respect to Fig. 2, are shown in communication with remote master devices 120, 122, 124, 126, and 128, as illustrated by thin arrows 150, 152, 154, 156, 158, 160, 162, 164, 166, 168. Each boarding pass communication device 102, 104, 106, 108, 110, or 112, has a limited range of communication and therefore will tend to communicate with the nearest remote master device 120, 122, 124, 126, or 128. Each remote master device 120, 122, 124, 126, or 128 has a broader range of wireless communication to enable communication with the nearest other remote master device, as illustrated by thick arrows 170, 172, and 174. However, as is well known, with modern industrial and domestic microwave heating devices and other communication devices, radio frequency interference is often a problem. Therefore, the present invention provides for direct communication between boarding passes and remote master, and for indirect communication between remote master devices using intermediate boarding pass devices. This is clearly shown in Fig. 3, where a boarding pass device 112 is shown creating a communications link between two remote master devices 124 and 128, thus allowing communication between devices 124 and 128 even if device 126 is inoperable. Also, a boarding pass device 106 that is outside the main terminal concourse 100 is shown communicating with a remote master 124 via another boarding pass device 108.

The system therefore has a "self healing" ability to allow one or more remote master devices to fail and still have the remaining devices communicate with each other and provide the required tracking facility. Furthermore, the communication range can be extended. In this way communication can be provided to a queue of passengers that extends into a region that is not intended to be ordinarily covered by the system.

Referring again to Fig. 3, the remote master devices are preferably provided in selected physical locations throughout the transportation terminal 100 in order to ensure that effective communication occurs. The overall effect is that passengers who have been issued with boarding pass devices tend to communicate with the nearest remote master device. Since passengers are usually moving through terminals, the passengers forming the slave clusters about each remote master device will be constantly changing, and Bluetooth technology protocol recognizes the changes as they occur. In this way, the system always knows where a particular boarding pass (which is identified by a unique identification number under Bluetooth protocol) is located by knowing which remote master is communicating with the boarding pass.

The Bluetooth network design according to the invention is described in greater detail below. Again, although the example describes use of the invention in an airport environment, it will be appreciated that the invention is applicable to many other industries. Reference is made to the network according to the invention as the Passenger Location network.

Expansion of Network Coverage

The Bluetooth network design allows for the creation of piconets, each consisting of up to 8 active nodes and up to 255 parked nodes. The range of Bluetooth devices is either up to 10 meters for normal power devices or up to 100 meters for high power devices. The Passenger Location electronic boarding passes have a range of up to 10 meters. A normal power Bluetooth device 100 meters away from a high power Bluetooth device is capable of receiving transmissions from the high power device, but the high power device cannot receive transmissions from the low power device at that distance.

In order to cover an area larger than that of a 10-meter radius with bi-directional communications encompassing low power devices using Bluetooth technology, some means of extending the coverage must be achieved. This can be accomplished by the use of multiple Bluetooth master devices capable of high power transmissions acting as message repeaters. Such high power master devices are referred to as "Remote Masters" in this document.

Remote Masters, for example devices 120, 124, 126, 128, are distributed throughout an airport in such a manner as to fully cover all areas of interest, including concourses and gate

areas. In general, each Remote Master is located within transmitting distance of at least two other Remote Masters. At one or more locations within the airport, a Remote Master is also connected to the airport's LAN 140, providing the bridge for data exchange between the Passenger Location network, comprising the boarding devices 102, etc. and the remote masters, 120, etc., and the airport LAN 140. By having more than one bridge between the Passenger Location network and the airport LAN and by having each Remote Master communicate with at least two other Remote Masters, the entire network is "self-healing" in regard to the loss of one or more nodes in the network.

Each Remote Master broadcasts any messages it receives from any other Remote Master. A Remote Master ignores any message repeated back to it that it originated, other than to use the echoed message as a confirmation that another Remote Master has received the message. In this way, any message generated by a Remote Master will find its way through some path to the airport LAN 140 and into the Passenger Location Application Server 146 attached to the airport LAN 140. The Passenger Location Application Server 146 ignores duplicate messages from Remote Masters. In a similar fashion, the Passenger Location Application Server 146 can send messages to any or all of the Remote Masters. Remote Masters are also able to transfers messages to and from any Bluetooth capable device, including mobile devices, for example the boarding pass devices, within range, meaning that the Passenger Location Application Server can communicate with those Bluetooth devices as well. For example, the Passenger Location Application Server can broadcast a flight status message to passengers for the particular flight, which can then be displayed or spoken to the passengers.

Mobile Units can also serve as temporary message repeaters. A mobile unit that cannot transmit a message to a Remote Master can ask another Mobile Unit to relay the message. The Mobile Unit serving as a temporary repeater can either transmit the message to a Remote Master or ask another Mobile Unit to relay the message. Eventually, the message will reach a Remote Master for relay or will arrive at the desired destination device. As is the case with a Remote Master, a Mobile Unite ignores any message repeated back to it that it originated, other than to use the echoed message as a confirmation that another device has received the message.

Communications is not limited to communications among the Bluetooth devices comprising the network. Remote Masters can be connected to other networks, such as an airport's Local Area Network (LAN). Via such connections, devices in the Bluetooth network can communicate with devices connected to the airport LAN. Messages can be targeted to a single destination device, a group of destination devices, all devices, devices of a certain type (e.g., Remote Masters), etc.

The network traffic generated by Mobile Units, Remote Masters, and devices connected to an external connected network is minimized by the use of local processing by the Remote Masters. Messages generated by devices contain two control fields that affect the "lifetime" of the messages. One of these control fields, referred to as "`RelaysRemaining`," contains the number of remaining relays permitted for the message. Each time a message is relayed, the `RelaysRemaining` field is decremented. The other control field, referred to as "`ExpirationTime`," contains the time the message should expire and cease to be relayed. . The two fields may be used independently or simultaneously, as indicated by additional control bits. In other words, a message may specify a maximum number of relays permitted, or an expiration time, or both.

If some external constraint prevents a segment of the Passenger Location network from being installed within range of a Remote Master on any other segment of the Passenger Location network, wireless Ethernet technology can be added to the network to provide the necessary connectivity. Although wireless Ethernet technology will be more expensive than Bluetooth technology, it has more range. In Fig. 4 a depiction of the combination of Bluetooth and wireless Ethernet technologies is shown.

Although it is not indicated explicitly in the diagram, a gate, for example gate 142, may contain more than one Remote Master. This is necessary for large gate areas. As with the configuration of other Remote Masters, such additional Remote Masters are located within transmitting distance of at least one other Remote Master.

Passengers holding Passenger Location Electronic Boarding Passes are located through a combination of techniques. Remote Masters cycle among three modes: a "listening" mode, "broadcast" mode , and a "query" mode. During the "listening" mode they are listening for identification messages from boarding passes or messages from other Remote Masters. During the "broadcast" mode, they transmit messages announcing their presence to Passenger Location Electronic Boarding Passes within range and repeat any messages received from other Remote Masters that require re-broadcast. During the "query" mode they query each known Boarding Pass as to its continued presence. Each Boarding Pass maintains a list of Remote Masters it currently hears, along with the associated RSSI (Return Signal Strength Indicator) measurements from the most recently received transmissions. Each Boarding Pass periodically broadcasts a message indicating its presence to the Remote Master having the strongest RSSI measurement. If the Remote Master responds, the Boarding Pass transmits its current list of Remote Masters and associated RSSI readings. Each Remote Master maintains a list of

boarding passes that have identified themselves. Associated with each boarding pass in the list is the list of Remote Masters and associated RSSI readings it transmitted to the Remote Master. Whenever a Remote Master hears from a boarding pass that is not already on its list, it sends a message to the Passenger Location Application Server 146 containing the location of the boarding pass. Optionally, depending on the overall network configuration, it may also pass along to the application server the Remote Master list and associated RSSI readings for the boarding pass. Periodically, each Remote Master sends a message out to any boarding passes it has not heard from in some specified period of time. If the boarding pass does not respond, the Remote Master removes the boarding pass from its list and sends a message to the Passenger Location Application Server indicating the pass has moved out of its range. The server stores all of the location information regarding boarding passes in a database server.

Using the technique described above, the Passenger Location Application Server will, *at all times*, know the location of all boarding passes that are within range of at least one Remote Master. Furthermore, it knows all of the Remote Masters for which a boarding pass is within range. If a boarding pass is within range of more than one Remote Master, its approximate location can be determined via simple triangulation. If a more precise location is required, each of the Remote Masters in view of the boarding pass can be queried for the last RSSI reading recorded. Using the precise location of the Remote Masters and the RSSI values, a location for the boarding pass can easily be computed to an accuracy better than 10 meters. The location can then be displayed graphically on a computer screen to aid in physically contacting the associated passenger.

The location of an individual Mobile Unit can be easily established within certain "zones" by consideration of which Remote Masters can be "seen" by the Mobile Unit at a particular point in time. Each Remote Master has a known range and location. If a particular Remote Master, for example Remote Master 512 in Fig. 5A, can receive a Mobile Unit's transmissions, then the Mobile Unit must be located within a distance from the Remote Master no greater than the Mobile Unit's transmission range. This distance is typically 10 meters. In such a situation, the Mobile Unit must be positioned somewhere within a 10 meter radial zone 502 of the Remote Master. If two Remote Masters, for example Remote Masters 512 and 514 in Fig. 5B, can receive a Mobile Unit's transmissions, then the Mobile Unit must be located within the overlapping region 517 of the two Remote Masters 10 meter radial zones. For each additional Remote Master that can receive the Mobile Unit's transmissions, the area within which the Mobile Unit must be positioned becomes smaller, for example Mobile Unit 522 in Fig. 5C can be precisely located. In addition, for multi-level environments in which Remote

Masters exist on different levels, the technique can be readily extended to locating Mobile Units in three dimensions. For an accurate three-dimensional location determination, at least four Remote Masters need to be employed. For example, if a boarding pass is within range of four Remote Masters, wherein at least one of the Remote Masters is on a different floor of an airport concourse from the other Remote Masters, the system can determine the floor location of the boarding pass.

The progressive refinement of a Mobile Unit's location described above requires closely spaced Remote Masters, since the approach is dependent upon each of the Remote Masters' ability to receive the Mobile Unit's transmissions. A refinement of the approach allows the spacing of the Remote Masters to exceed the transmission range of the Mobile Unit. The refinement takes into consideration the transmission range of the Remote Masters. Consider a Mobile Unit located at a distance from a Remote Master, for example 514 in Fig. 5B, farther than its transmission range of 10 meters, but less than the transmission range of the Remote Master (typically 100 meters). Further assume the Mobile Unit is located within its transmission range (10 meters) of another Remote Master, 512. The Mobile Unit is then able to inform Remote Master 512 that it can receive the transmissions of Remote Master 514. It is then clear that the Mobile Unit lies within the intersection of the 10-meter radial zone around Remote Master 512 and the 100-meter radial zone round Remote Master 514. The Mobile Unit can inform a Remote Master of additional Remote Masters it can hear, further refining the location determination, as accomplished before.

The accuracy of the determination of a Mobile Unit's location can be significantly improved by taking into account the Return Signal Strength Indicator (RSSI) measurement that is available when receiving a transmission. Not only can the Mobile Unit take note of which Remote Masters it can hear, it can also pass along the RSSI measurements for the received transmissions. By using the RSSI values, which are inversely proportional to the square of the distances from a transmitter, coupled with the known broadcast power of the Remote Masters, the locations of Mobile Units can be improved from "zones" to specific distances using well-known triangulation techniques.

The positioning of the Remote Masters in relation to one another is important. Situations exist in which it is acceptable to have "holes" in coverage, i.e., locations in which no Remote Master can hear a Mobile Unit, and situations in which continuous coverage is important. The necessary coverage is entirely application dependent. Generally, it is desirable to limit configurations in which holes exist to those configurations in which a Mobile Unit cannot leave the area without passing within its transmission range of a Remote Master. For example, it may

not be necessary to provide complete coverage of a hallway or corridor. Rather it may suffice to have Remote Masters located only at the entrances/exits of the area, such that a Mobile Unit cannot leave the area without a Remote Master knowing about it. However, it is probably still desirable to have overlapping coverage of the Remote Masters with one another so as to provide the "self-healing" characteristic of the system, as described elsewhere in this document. Areas for which there is only one entrance/exit, such as a restaurant on an airport concourse, may also not require continuous coverage.

The location can be determined still more precisely by altering the transmitting power of the transmitting device or the receiver sensitivity of the receiving device, or both. It is well known that a link budget can be calculated between a first transmitting device of known power and a second receiving device of known input sensitivity. Thus, the maximum distance between the two devices can be estimated. Alternatively, the maximum distance between the two devices can be measured experimentally at the time of manufacture. Thus, if two devices are close enough to communicate—both devices having known Radio Frequency (RF) power outputs and known input sensitivities—then it is known that the devices are within their maximum ranges for those values.

Using this information, either device can command the other device to reduce its output power or input sensitivity until communication fails. Using the power or sensitivity levels at which communication fails, and using a table of the maximum ranges for each combination of RF power outputs and input sensitivities of the two devices, then the maximum range of the devices is determined.

For example, assume, device A has enough output power to communicate given the present state of input sensitivity of device B, and device B has enough output power to communicate back given the present state of input sensitivity of device A. Device A commands device B to reduce its output power and report back to A. Device A receives a transmission from device B, and so knows that Device B is inside the maximum range defined by previous testing of various combinations of B's output power and A's input sensitivity. Since the communication is still possible between B and A, A again commands B to reduce its output power and report back to A. This process repeats itself until Device A receives no transmission back from B. Since A knows the last known reportable state of device B's output power, device A looks up the range for the combination of A's input sensitivity and B's output power, and thus determines the range between the two devices.

If a boarding pass is not in range of any Remote Master, it is still possible for the pass to be located. Passenger Location Application Server 146 can broadcast a "Search and Rescue"

message to the network. Such a message is passed on to all of the boarding passes within range of the Remote Masters. The boarding passes then attempt to communicate directly with any other boarding passes within range to broadcast the message further, thereby extending the Passenger Location Network temporarily. In this manner, a pass, for example pass 106, that is not within range of any Remote Master, but is within the range of at least one other boarding pass 108 will receive the "Search and Rescue" message and respond back through the other boarding pass into the Passenger Location Network.

Network Traffic

The network traffic generated by the Passenger Location Electronic Boarding Passes, the Remote Masters, and the Passenger Location Application Server is reduced by the use of local processing by the Remote Masters. By limiting the messages from the Remote Masters to the Passenger Location Application Server to changes in status of a boarding pass, only the minimum amount of information regarding a boarding pass is transmitted to the server. When a boarding pass moves within the coverage of a Remote Master(s), but does not change which Remote Master(s) is in view, no information is transferred between the Remote Master and the server, although the RSSI information for the pass is updated in the Remote Master(s). The RSSI data is not normally transmitted to the server unless specifically requested, however, in certain applications the RSSI data is sent to the server with each message, so that the server can readily determine a more precise location of a boarding pass.

The "Search and Rescue" message scenario need only be invoked when a message must be sent to a boarding pass that is not currently communicating with any Remote Master.

Network Redundancy

The Passenger Location Network is inherently "self-healing" as a result of the techniques used to extend the Bluetooth network. By using the Remote Masters as repeaters who broadcast all messages received from other Remote Masters and by having many Remote Masters connected to the Airport LAN, many redundant pathways for network traffic are automatically created and utilized as necessary.

The Process Flow

When a passenger checks in at the airport terminal, the passenger is issued a boarding pass devices, such as device 10 (Fig. 1) or device 20 (Fig. 2). The pass device may be issued along with a standard paper pass, and could be used as a clip to keep the paper document and

ticket etc attached to each other, as shown above in Fig. 2. Before or at the time the pass is given to the passenger, data about the passenger is transmitted to the pass by the airline or the handling agent. This may occur in any number of formats, but is preferably via a standardized flat file. This data can, for example, be encoded to ensure the passenger name is never revealed but that the pass uses a passenger ID provided by the airline. The system always knows where a pass is at any time, so the system can now provide tracking information to the airport. The tracking information is provided to the airport only, so no one has access to both passenger identification and passenger tracking.

A dispenser machine is provided having a magazine that is loaded with passes. Batteries in the passes may be inductively charged in the magazine. As each pass is taken from the magazine by the dispenser, the pass ID is read and passed to the database to connect the pass ID to the passenger ID. The pass "pops" out from the dispenser when the paper boarding pass is printed, so it is immediately available to hand to the passenger.

When the passenger boards the aircraft, the pass is returned for reuse. At this point a pass receiving machine is provided having an entry slot. In one embodiment, a pass can only be inserted in one orientation. Thus as each pass is received it is oriented in a known way and may be stacked in a magazine. At any time or when the magazine is full, it can be removed and taken to the dispenser machine. The receiver or dispenser machines can also have an inductive charger for charging the batteries in the passes. Each magazine can be spring loaded and the receiver or dispensers will preferably be able to read the number of cards in a magazine at any given time.

If the scheduled departure time is approaching, an automated message may be sent to passengers who have not boarded requesting that they go to the gate. This may take the form of a message displayed on the screen, and/or an audible message, or lighting of an LED. The passenger may be prompted to respond to the message by pressing a key for example, or by sending a voice response. If there is no response within a further time period, or if the passenger has not passed the gate, then staff may be sent to search for the passenger based on the pass location reported by the system.

In the time between obtaining the pass and boarding the aircraft, the passenger may be provided with shopping information, such as special prices for various items on sale in airport shops. The system may also have general content that the user may access using the pass. For example, such content may include news items or maps (showing actual passenger position) of the terminal. Furthermore, since the invention is compatible with Bluetooth, the system may provide a communications platform for other devices used by passengers. For example, a

passenger with a Bluetooth enabled notebook could use the airport LAN to communicate with an ISP. Many other communication options are possible.

While the user makes his or her way through the terminal the system records the tracking data. This may be used to record passenger flows for analysis of bottlenecks, retail revenue and marketing purposes. It will be seen that the invention allows a specific advertisement to be provided to a user when that user is in the vicinity of a relevant retail outlet in the terminal.

If within a certain time prior to departure, one or more passengers is not shown as even being in the airport, then a "hotlist" may be provided by the system to the flight controller, and this can be used to begin unloading the relevant luggage to ensure that the flight is not delayed.

It will be seen that transit passengers may be provided with a pass when leaving the plane and the pass may be used to alert the transit passenger if he or she strays into a wrong part of the terminal. The pass will also provide those passengers with the advantages described above.

Although the remote master machines shown in Figs. 3 and 4 are intended to remain at selected locations within the terminal, mobile masters may be provided, for example being Bluetooth enabled PDA devices having appropriate software to operate with the system. These devices may be used to locate passengers who have not responded to a page instruction. They may also be capable of displaying a photograph of the missing passenger that could be downloaded from the system database.

Each gate, for example gate 142 in Figs. 3 and 4, contains a gate hub 180 to interface with the airport LAN 140. Each gate hub preferably, but not necessarily, is also connected to a computer system 182 which contains system application software. In this way staff at the gate can use various system features, for example interrogate the system on the location of tardy passengers, page passengers, or send general information such as a boarding call. Furthermore, each gate hub is connected to a boarding pass reader 184. This preferably has a limited range, and will communicate with any boarding passes in the immediate vicinity of the reader to read the identity information for the system. Thus, as each boarding pass passes the gate reader, the system will be updated with information that the relevant passenger has entered that gate.

In summary, the invention provides numerous advantages, most of which are evident from the foregoing description. The most significant are: the ability to interact with passengers while also tracking, for example by broadcasting information to passengers and await a response; the provision of a general purpose communications platform throughout the terminal; and the real time recording of tracking data for analysis purposes.

It will be seen that inanimate objects may also be tracked, and that the system may be used in outdoor environments or on very large scales by including a GPS receiver in the tracking device. Various checkpoints having remote master devices can communicate relevant data as the tracking device passes the checkpoint. Thus the invention may also be used in other transportation industries, equipment location or communications, employee badging, service industries, retail stores, courier or delivery applications.

CLAIMS

What is claimed is:

1. A method for tracking objects within a predefined area, said method comprising the steps of:

   (a) assigning a pass device, containing a pass device identifier, to each object as said object enters said predefined area, and storing said identifier in a server device;

   (b) periodically wirelessly transmitting said identifier by said pass device to at least one remote master device on a remote master device network within said predefined area;

   (c) when a remote master device receives an identifier from a pass device, sending said identifier and a location of said remote master device to said server device wherein said server device stores said identifier and a location of said object as said location of said remote master device; and

   (d) when each object leaves said predefined area, unassigning said pass device from said object.

2. The method of tracking objects of claim 1 further comprising the step of:

   (e) when a remote master device receives a communication from a pass device, and said remote master device cannot communicate directly to said server, said remote master device sends said identifier received from said pass device, along with a location of said remote master device, to a second remote master device wherein said second remote master device sends said identifier and said location of said remote master device to said server.

3. The method of tracking objects of claim 1 further comprising the step of:

   (e) when an object is to be removed from said predefined area, sending a removal communication to a remote master device that last communicated with said pass device assigned to said object which further sends said removal communication to said pass device.

4. The method of tracking objects of claim 3 further comprising the step of:

   (f) when a removal communication needs to be sent to a pass device for an object and said pass device cannot be located through said remote master device network, sending a rescue message to all remote master devices within said

remote master device network, wherein said rescue message is sent to all pass devices known to each remote master device, wherein each pass device receiving said rescue message further transmits said rescue message to any pass device within transmitting range of said pass device, wherein a pass device outside a transmitting range of any remote master device, but within a transmitting range of at least one pass device communicates its identifier, and thus its location to said server.

5. The method of tracking objects of claim 1 further comprising the step of:
   (e) when a remote master device in said remote master device network is not available, and messages from a first remote master device on a first side of said unavailable remote master device cannot be sent through said unavailable remote master device to a second remote master device on a second side of said unavailable remote master device, sending said messages to any pass device in communication with said first remote master device and said second remote master device wherein said unavailable remote master device is bypassed.

6. The method of tracking objects of claim 1 wherein said objects comprise airline passengers.

7. The method of tracking passengers of claim 6 further comprising the step of:
   (e) when a location of a passenger is within a predetermined distance of a retail location within said predetermined area, sending an advertising communication to said pass device assigned to said passenger and displaying said advertising communication on a display device in said pass device.

8. The method of tracking objects of claim 1 wherein at least one pass device comprises a cellular telephone.

9. The method of tracking objects of claim 1 wherein at least one pass device comprises a personal digital assistant device.

10. The method of tracking objects of claim 1 wherein said remote master device network further comprises at least one wireless Ethernet device in communication with a remote

master device wherein said at least one wireless Ethernet device communicates with said server device.

11. The method of tracking objects of claim 1 further comprising the step of:
   (e) sending an Internet communication from a pass device to a remote master device and further sending said Internet communications from said remote master device to said server device and further sending said Internet communication from said server device to at least one Internet device.

12. The method of tracking objects of claim 1 further comprising the step of:
   (e) when a pass device is within transmitting distance of at least two remote master devices, determining a precise location of said pass device by measuring a signal level of at least one transmission from said pass device in each of said at least two remote master devices and triangulating said precise location.

13. A method for tracking passengers within a predefined departure area, said method comprising the steps of:
   (a) providing a pass device, containing a pass device identifier, to each passenger as said passenger checks in for departure, and storing said identifier in a server device;
   (b) periodically wirelessly transmitting said identifier by said pass device to at least one remote master device on a remote master device network within said predefined area;
   (c) when a remote master device receives an identifier from a pass device, sending said identifier and a location of said remote master device to said server device wherein said server device stores said identifier and a location of said passenger as said location of said remote master device; and
   (d) when each passenger boards a transportation vehicle, collecting said pass device from said passenger.

14. The method of tracking passengers of claim 13 further comprising the step of:
   (e) when a remote master device receives a communication from a pass device, and said remote master device cannot communicate directly to said server, said remote master device sends said identifier received from said pass device, along

with a location of said remote master device, to a second remote master device wherein said second remote master device sends said identifier and said location of said remote master device to said server.

15. The method of tracking passengers of claim 13 further comprising the step of:

(e) when a passenger is to be boarded on a transportation vehicle, sending a boarding communication to a remote master device that last communicated with said pass device provided to said passenger which further sends said boarding communication to said pass device which displays said boarding communication to said passenger.

16. The method of tracking passengers of claim 15 further comprising the step of:

(f) when a boarding communication needs to be sent to a pass device for a passenger and said pass device cannot be located through said remote master device network, sending a rescue message to all remote master devices within said remote master device network, wherein said rescue message is sent to all pass devices known to each remote master device, wherein each pass device receiving said rescue message further transmits said rescue message to any other pass device within transmitting range of said pass device, wherein a pass device outside a transmitting range of any remote master device, but within a transmitting range of at least one pass device displays said boarding communication to said passenger provided with said pass device.

17. The method of tracking passengers of claim 13 further comprising the step of:

(e) when a remote master device in said remote master device network is not available, and messages from a first remote master device on a first side of said unavailable remote master device cannot be sent through said unavailable remote master device to a second remote master device on a second side of said unavailable remote master device, sending said messages to any pass device in communication with said first remote master device and said second remote master device wherein said unavailable remote master device is bypassed.

18. The method of tracking passengers of claim 13 wherein at least one pass device comprises a cellular telephone.

19. The method of tracking passengers of claim 13 wherein at least one pass device comprises a personal digital assistant device.

20. The method of tracking passengers of claim 13 wherein said remote master device network further comprises at least one wireless Ethernet device in communication with a remote master device wherein said at least one wireless Ethernet device communicates with said server device.

21. The method of tracking passengers of claim 13 further comprising the step of:
(e) sending an Internet communication from a passenger through a pass device provided to said passenger to a remote master device and further sending said Internet communications from said remote master device to said server device and further sending said Internet communication from said server device to at least one Internet device.

22. The method of tracking passengers of claim 13 further comprising the step of:
(e) when a pass device is within transmitting distance of at least two remote master devices, determining a precise location of said pass device by measuring a signal level of at least one transmission from said pass device in each of said at least two remote master devices and triangulating said precise location.

23. The method of tracking passengers of claim 13 further comprising the step of:
(e) when said location of a pass device provided to a passenger is within a predetermined distance of a retail location within said predetermined departure area, sending an advertising communication to said pass device assigned to said passenger and displaying said advertising communication on a display device in said pass device.

24. A system for tracking objects within a predefined area, said system comprising:
a server device for assigning an identifier to each object being tracked;
a network comprising a plurality of wirelessly connected remote master devices, each located within said predefined area wherein each remote master device can

wirelessly communicate with at least one other remote master device and further wherein at least one remote master device communicates with said server device;

a pass device for each object being tracked, wherein a pass device can wirelessly communicate to at least one remote master device and wherein an identifier is sent to each pass device by said server when said pass device is connected to said object;

wherein a pass device is connected to each object as the object enters the predefined area and further wherein each pass device periodically communicates to at least one remote master device to send said identifier from said pass device to said remote master device and still further wherein said remote master device sends said identifier, and a location of said remote master device, to said server which stores the identifier and the location, thus the location of the object, stored in said server, is within a transmitter range of the remote master device receiving the communication, and further wherein as the object moves within the area, the location of the object is maintained by communications to remote master devices and said server.

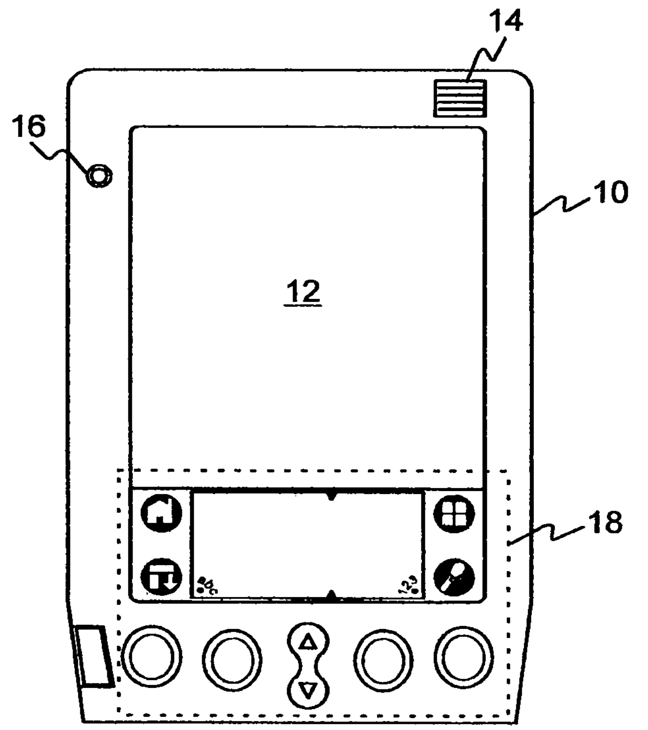


FIG. 1

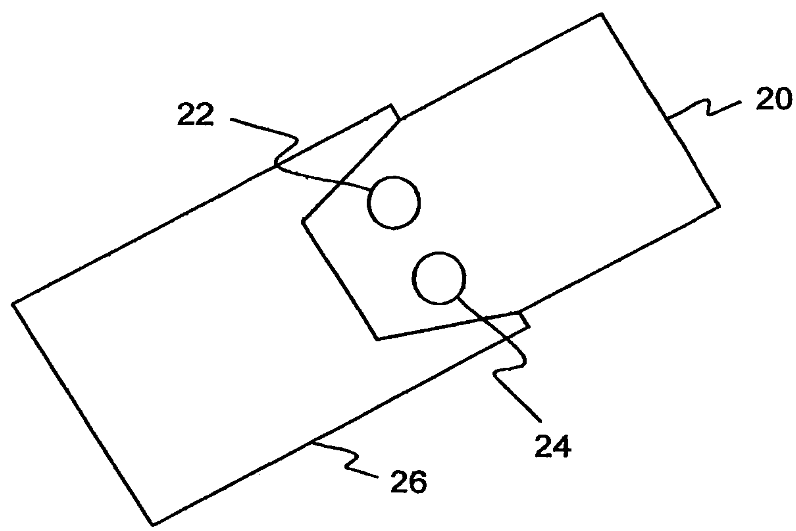
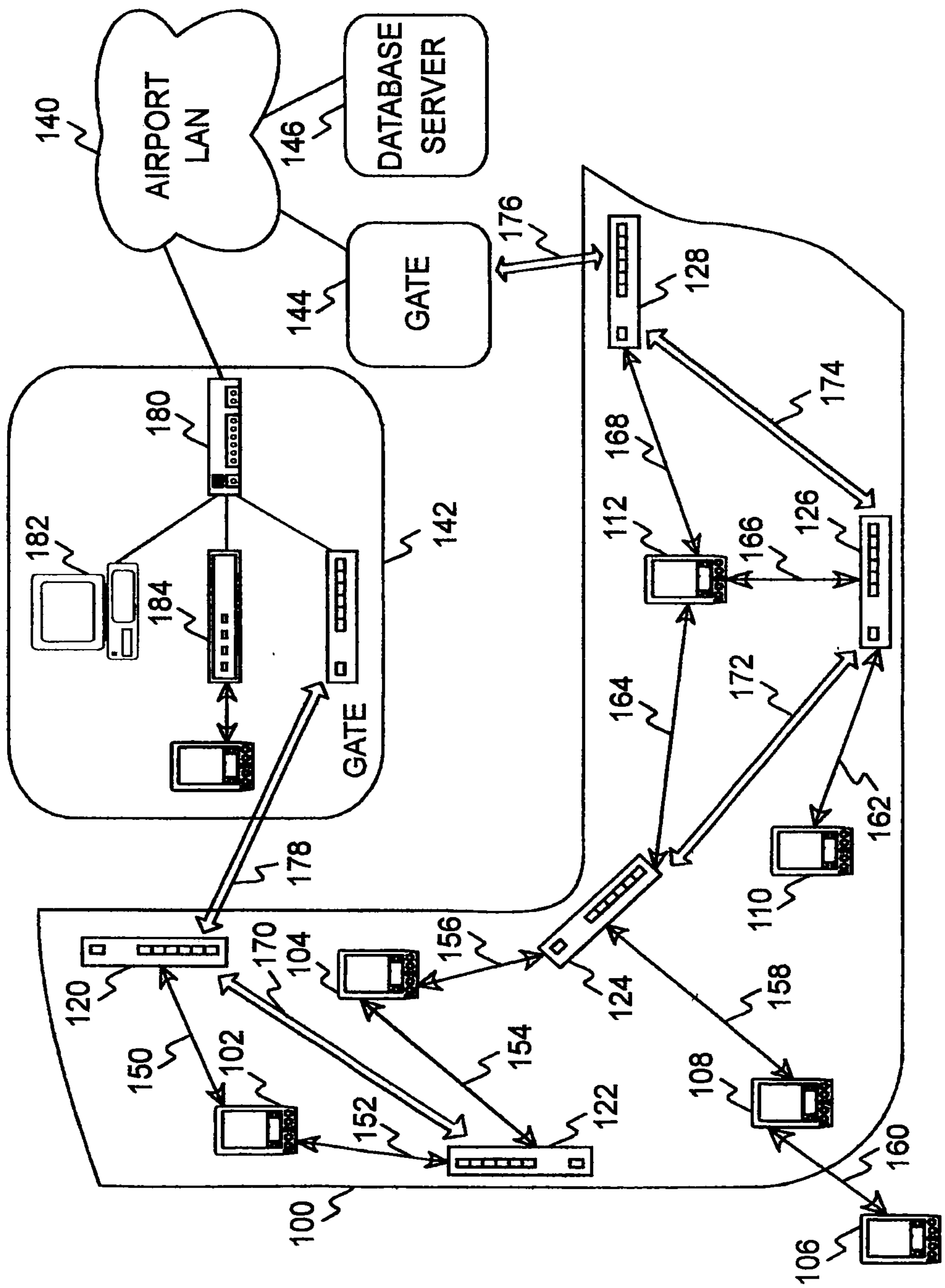


FIG. 2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DATABASE SERVER
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GATE
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176
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GATE
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126
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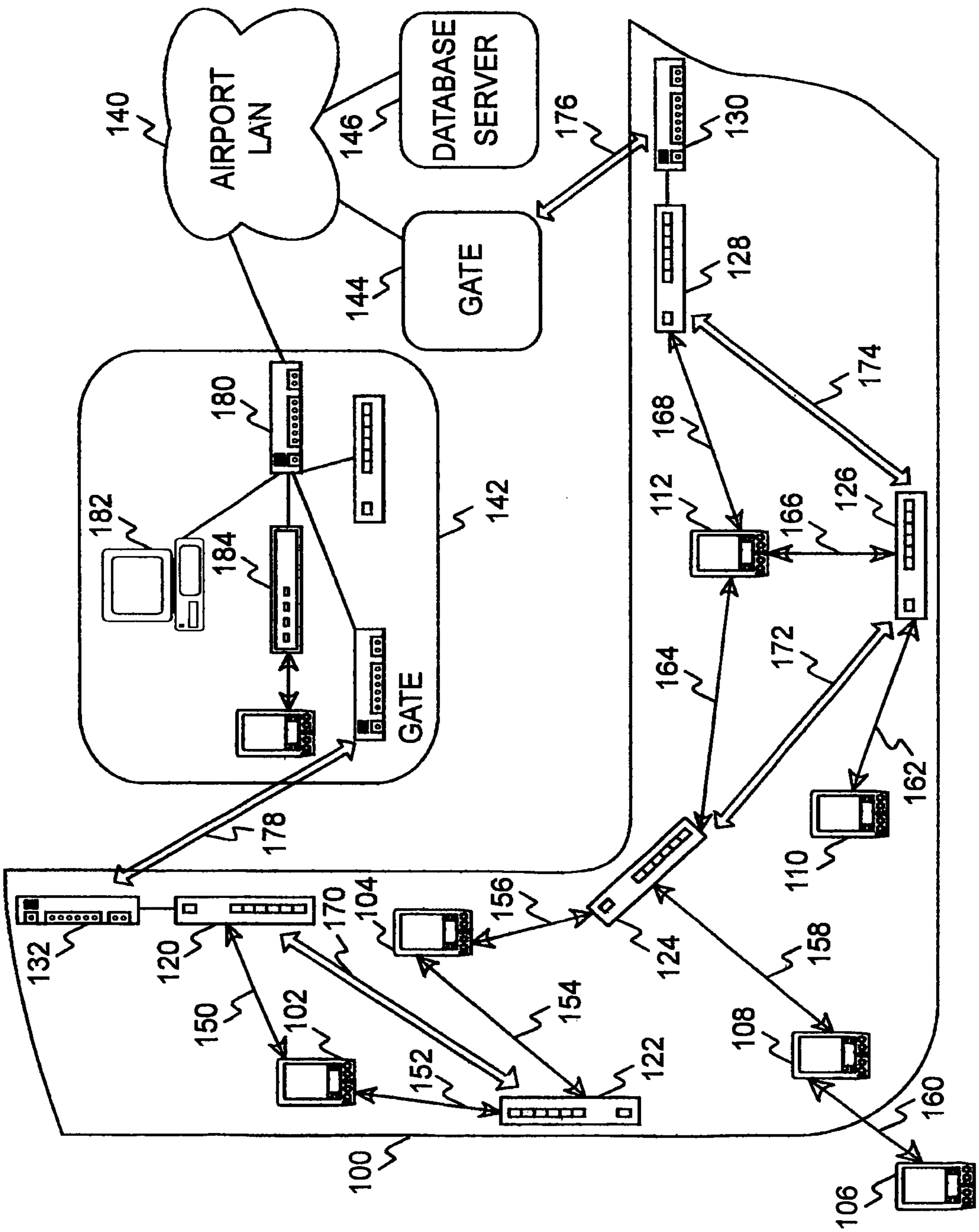
FIG. 3


AIRPORT LAN
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DATABASE SERVER
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GATE
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FIG. 4

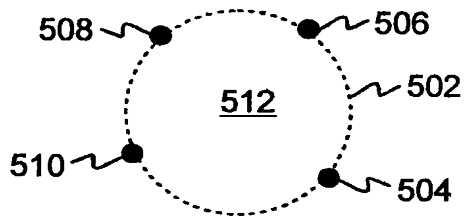

FIG. 5A

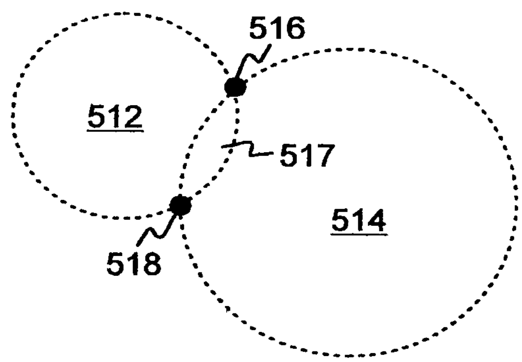

FIG. 5B

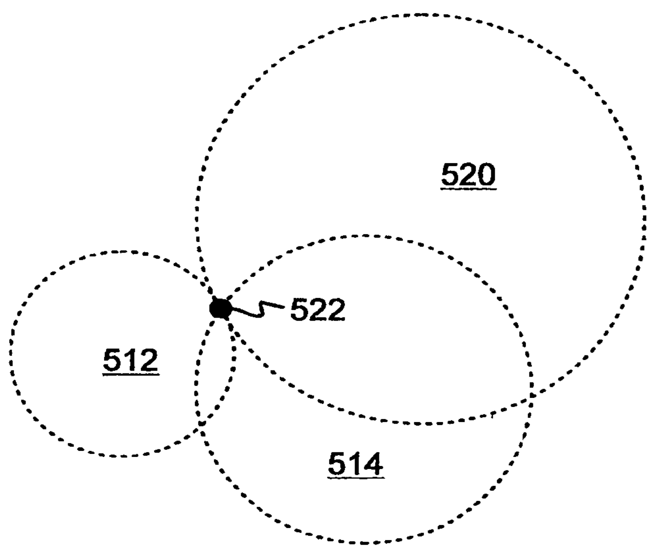

FIG. 5C

INTERNATIONAL SEARCH REPORT	International application No. PCT/US02/29328

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06F 15/00, 15/02; G08B 23/00; H04Q 5/22; H04B 7/185

US CL : 340/10.42, 10.6, 825.49, 573.4, 539; 342/357.07, 357.09, 419; 235/384; 455/95

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/10.42, 10.6, 825.49, 573.4, 539; 342/357.07, 357.09, 419; 235/384; 455/95

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST/WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,652,570 A (LEPKOFKER) 29 July 1997 (29.07.1997), see entire document.	1 - 24
Y	US 5,051,565 A (WOLFRAM) 24 September 1991 (24.09.1991), see entire document.	1 - 24
Y	US 5,929,849 A (KIKINIS) 27 July 1999 (27.07.1999), see entire document.	1 - 24
Y	US 6,252,544 B1 (HOFFBERG) 26 June 2001 (26.06.2001), see entire document.	1 - 24

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 16 October 2002 (16.10.2002)	Date of mailing of the international search report 06 DEC 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Yves Dalencourt Telephone No. (703) 308-8547

Form PCT/ISA/210 (second sheet) (July 1998)